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EDITORIAL

CHANGING CONDITIONS ARE A SPUR TO FURTHER EFFORT

VETERINARY surgeons who are of mature age have witnessed great diversity in the type of service that is required by their clients. There has been a great veer in method, in the medicinal agents used, and also in the manner of approach to, or contact with, both patient and client.

If a competent practitioner of some forty years ago was suddenly transplanted into a modern practice he would be like a sailor who was called upon to navigate an aeroplane over the sea. The sea might be the same, the sailor would still possess the basic navigational knowledge of his craft, but he would be at some disadvantage for want of knowledge of his new ship.

An old veterinary surgeon would be in a similar dilemma. He would find that the service demanded by his clients had undergone revolutionary change. His mode of transport, his drugs, his instruments would be entirely different from those he had been accustomed to use, and, not least, the method of approach and speech with the client would be changed also. If he wished to resume his work and cope efficiently with modern conditions a period of apprenticeship in a busy practice would be necessary.

During his forty years of absence the relative importance of the various species has altered. The prosperous horse practitioner has lost his exalted place to the cow-leech. The wheel has turned from horse to dog, and from dog to cattle. For some time the milch cow has been the patient of prime importance,

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both scientifically and economically. The exigencies of war accentuated this transition, for milk came to full recognition as a valuable and essential food during that period. Milk went far to compensate for deficiencies in diet, and, moreover, it was a product which could be produced in our besieged island home. Farmers reacted nobly to the call for more milk; it sometimes meant a complete change in their traditional methods of husbandry. They were encouraged by the economic returns and they waxed prosperous.

Veterinary surgeons benefited also, for their services were in great demand. Milk brought prosperity to the profession, just as the demands of transport had done to an earlier generation.

It was good that this door should open, for mechanisation and the shortage of animal foodstuff had caused a great decline in the numbers of horses, pigs and poultry. Veterinary practice was orientated to suit the new conditions, and practitioners almost lived with, and talked of nothing else but the milch cow. Papers and discussions at society meetings were monopolised by the cow.

This great change in work and outlook was no new thing to the profession. It had happened before under other circumstances, the last time being when the small animals rose to a position of prominence.

The past helps one to foretell the future, and there are signs that another change is in being, for farm life is in process of orientation to altered conditions. The world shortage of meat is the pre-eminent factor to-day. Home production must be increased. This means that store cattle, pigs, sheep and poultry come into the picture to a degree far greater than has been the case over the last two decades.

There are signs that this may be to the detriment of the milk industry. Economics play their part, for it is simpler to produce meat than to produce milk. Farming with " a dog and a stick " reduces the intensity of the farmer's financial headaches.

Traditional beef areas may return to beef production. This will affect the veterinary surgeon, for his services are not required so frequently on the stock farm as on the dairy farm. Pigs and poultry are increasing rapidly in numbers, and in concentration.

Nature has a rule which may be applied to any species of animal: " The amount of disease is proportionate to numbers and concentration." Already we see signs of this inflexible rule amongst the pigs.

We must try to circumvent nature, otherwise all the efforts to increase food supply of animal origin will be affected seriously. Much knowledge is available to help us in this endeavour. If veterinary surgeons and the stock rearers co-operate many dangers can be avoided, for disease can be controlled, and even averted.

If the opportunity is grasped there will be plenty of food and plenty of work for the profession.

If one door should close there is another available to be opened by those who are willing and ready.

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GENERAL ARTICLES

A NOTE ON FRUCTOLYSIS AND OTHER CHARACTERISTICS IN BULL SEMEN

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THE seminal fluid of animals contains a reducing carbohydrate which Mann (1946, *a, b*) has shown to be d(—)-fructose. The rate of fructolysis is correlated with both the density and motility of the spermatozoa and can be used as the basis of a quantitative evaluation of semen (see Anderson, 1945; Mann, 1948, *a, b*). The change in *pH* and the final *pH* of semen on incubation are also correlated with the density and motility of spermatozoa (Anderson, 1944, 1947; Laing, 1945; Reid, *et al.*, 1948). The *pH* change and fructolysis are both measures of spermatozoal metabolic activity, but the latter, which gives a direct estimation of fructolysis, is probably the better of the two, though the *pH* change test has the advantage of being simple and quick (Reid, *et al.*, 1948). It is the purpose of this paper to describe the relationship observed between the *pH* change, fructolysis, and other characteristics of bull semen.

Material and Methods

Semen was collected in the usual way with the artificial vagina.

Sugar was estimated either by Harding's modification of the Schaffer-Hartman method or by Haslewood and Strookman's method (see King, 1946). The sugar was determined on collection and after incubation for one hour at 37 degrees C., and the reduction expressed as a percentage of the initial value.

The methods used for determining the change in *pH* on incubation for one hour at 37 degrees C., the buffer capacity (B.C.) and the specific gravity (S.G.) have already been described (Anderson, 1946, *a*; 1947).

Results

The relationship between the percentage fructolysis and the initial *pH* of the semen, the buffer capacity and the specific gravity of the seminal fluid, the density of the spermatozoa and the *pH* change is shown in Table 1 and Figs. 1, 2, 3 and 4. There is considerable scatter of the individual results in the diagrams, but the mean data show a direct correlation between the percentage fructolysis and the *pH* change; higher values for both are associated with a greater density of sperm, a higher *pH*, a poorer buffer capacity, a lower specific gravity, and vice versa.

The mean value for fructose in whole semen on collection was 485 mg./100 ml. semen, and after one hour at 37 degrees C. it had fallen to 350 mg., a reduction of 28.6 per cent. The *pH* change for the same specimens was —0.61. Within the range 10-49 per cent. reduction in fructose, there was no relationship between fructolysis and fructose content (mean = 523 mg.), but for the range 0-9 per cent fructolysis, the fructose content was 309 mg. (four specimens). There was no obvious relationship between fructolysis and motility, though motility

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tended to be poorer, with lower (under 9 per cent) and higher (over 40 per cent) fructolysis.

The average rate of fructolysis for 18 specimens of good initial motility (80-100 per cent) and density (5-19 x 10^8 sperm/ml.) was 1.55 mg./10^9 sperm/1 hr. at 37 degrees C. (range 0.1-3.2 mg./10^9 sperm/1 hr.). Three first ejaculates from different bulls gave no fructolysis: (1) No motility, density 7.5 x 10^8 sperm/ml., *pH* change +0.11; (2) motility 80 per cent, density 1.1 x 10^8 sperm/ml., *pH* change +0.31; (3) motility 50 per cent, density 5 x 10^8 sperm/ml., *pH* change —0.07.

Discussion

Mann (1948, *a, b*) has shown that when fresh semen alone is incubated *in vitro,* the fructose disappears rapidly at first, but later, owing to the fall in *pH,* more slowly or not at all, but with the addition of a suitable quantity of phosphate buffer, fructolysis can be maintained at a steady rate for several hours, and under such conditions the disappearance of fructose follows a linear course until practically the entire sugar content is exhausted. Mann's graph shows that after one hour's incubation at 37 degrees C. there is little difference in the fructose content in non-buffered and buffered semen, but with longer periods of incubation there is considerably less fructolysis in non-buffered semen. It would therefore seem that conditions in whole semen are not inimical to fructolysis for this period of incubation and that estimations of fructolysis and the *pH* change would give comparable results. However, it appears that the initial *pH* of semen does affect the rate of fructolysis, for the more alkaline the semen the greater was the fructolysis (Table 1). It has also been shown previously that when spermatozoa were suspended in fluids of known composition, the higher the *pH,* within the experimental limits, the greater was the *pH* change (Anderson, 1947). In whole semen, however, it was noted that the lower the initial *pH,* the greater was the *pH* change (Anderson, 1944), and the greater the motility and density of spermatozoa. Thus, high quality semen, implying a lower initial *pH,* and a higher density and activity of spermatozoa does not supply the ideal conditions for maximum metabolic activity, for the greater metabolic activity of such spermatozoa cannot be expressed because of the relatively unsuitable *pH.* Mann (1948, *b*) states that the shift of *pH* by itself cannot disclose the full extent of glycolytic ability of semen, being the outcome not only of the quantity of acid produced by spermatozoa, but also, and to a variable extent, of the buffering capacity of any given sample of semen. The direct estimation of fructolysis in buffered semen thus appears to give a better estimate of metabolic activity than that given by the *pH* change.

Mann remarked that semen samples with a notoriously low fructose content are those from animals with a poor fertility record (1948, *b*). No correlation has been observed between the fructose content, the density of spermatozoa and the initial motility (Anderson, 1946, *a*). A low sugar content is more commonly found in the first ejaculate, which is usually of poorer quality than second ejaculates (in the present series, the lowest fructose content noted was 283 mg.

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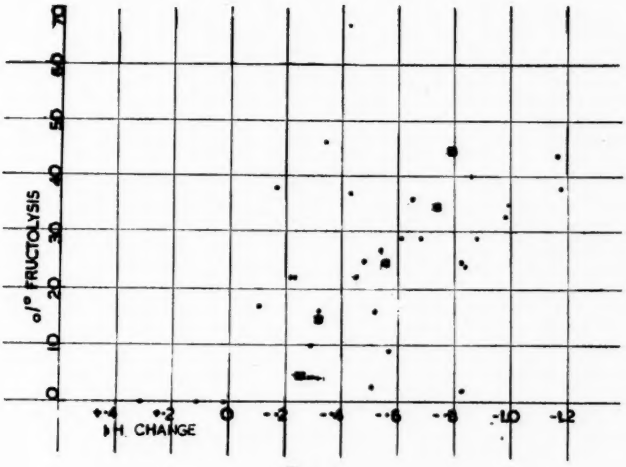

FIG. 1

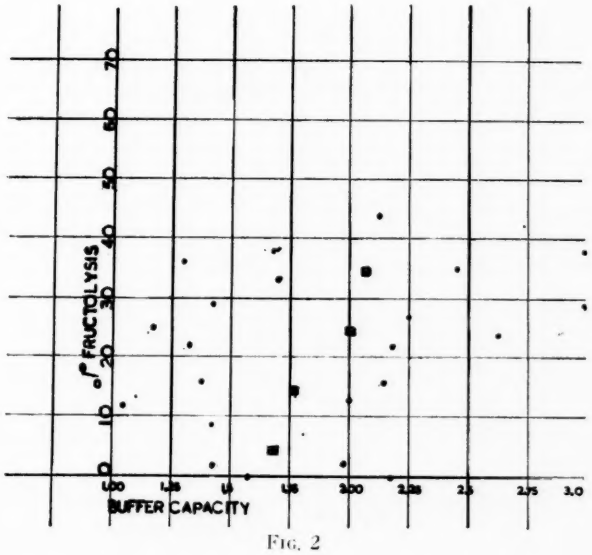

FIG. 2

(Article by Anderson, page 435)

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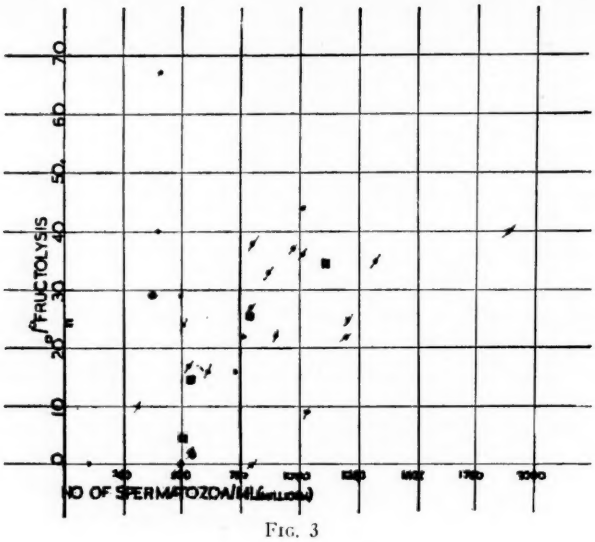

FIG. 3

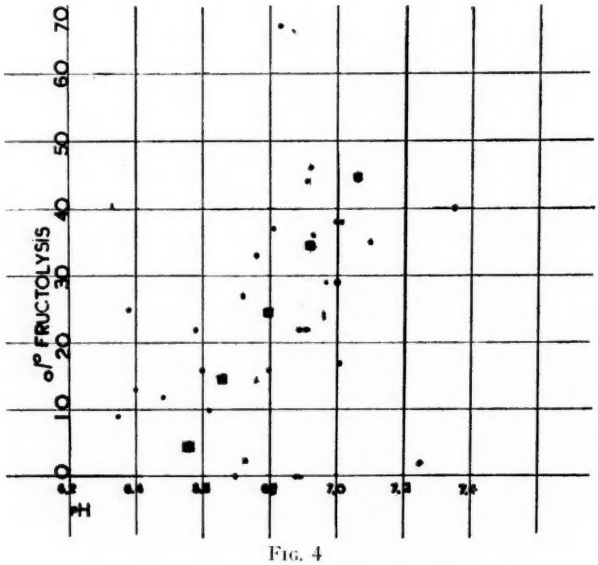

FIG. 4

(*Article by Anderson, page* 435)

per cent, in a first ejaculate of initial motility 80 per cent, density 1.1 x 10^9 sperm/ml., *pH* 6.89, and *pH* change +0.31); second ejaculates of low fructose content all had a small number of spermatozoa (2.2 x 10^8 sperm/ml.; Anderson, 1946, *b*). On the other hand, Mann (1948, *b*) has shown that the fructose content can vary independently of the sperm density.

It has been found that the more acid the seminal fluid the better was the buffer capacity and the higher the specific gravity, which is supported by the data in Table 1, and also the fructose content (Anderson, 1946, *a, b*). Previously, no significant relationship was observed between the *pH* change and the specific gravity of the semen or the buffer capacity of seminal fluid (Anderson, 1946, *a*), whereas the present data show that a higher fructolysis and *pH* change is associated with a poorer buffer capacity and a lower specific gravity of seminal fluid. The relationship between certain qualities of seminal fluid on the one hand—*pH*, buffer capacity, specific gravity and fructose content—and those of spermatozoa on the other — metabolic activity as evidenced by fructolysis and *pH* change—is of a general and indirect nature in that high quality spermatozoa are commonly associated with high quality seminal fluid, and vice versa, i.e., there is a correlation between androgenic and spermatogenetic function, but they can, and do, vary independently of each other.

TABLE 1.

Per cent Fructolysis.

	No. of specs.	0-9	10-19	20-29	30-39	40-49	50-59	60-69
Initial *pH*	31	6.76	6.66	6.80	6.92	7.06		6.83
Buffer capacity ...	20	1.71	1.76	1.99	2.06	2.12		
Specific gravity ...	14	0.0388	0.0275	0.0315	0.0256			
No. of sperm. Mil./ml.	28	507	548	788	1,112			
pH change	29	—0.26	—0.32	—0.56	—0.74	—0.79		

Summary

A direct relationship has been observed between fructolysis and the change in *pH* on incubation of bull semen, higher values for both being associated with a higher initial *pH*, a poorer buffer capacity, and a lower specific gravity of the seminal fluid. The direct estimation of fructolysis appears to give a better estimate of spermatozoal metabolic activity than the *pH* change.

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A MODERN APPROACH TO SUCCESSFUL PIG PRODUCTION

By W. P. BLOUNT.

It is not generally realised that the number of embryo piglets conceived, following mating, is usually much greater than the number of young born. This is because a number of the embryos die and are resorbed, and in many cases this is probably related to lethal factors of genetic origin.

The development of the embryos is slow at first, but the impetus gained is seen remarkably during the last 3-4 weeks of the gestation period, and it is at this time that a generous balanced ration is needed. For this purpose Sow & Weaner and not " fattening " rations are required.

A sow carrying a litter of twelve, on the average will produce 36 lb. of pig-meat at farrowing time, for which, of course, 4 lb. of meal will be required for each 1 lb. live-weight gain; hence the common practice of feeding such pregnant sows not less than 5 lb. of balanced pig nuts scattered on the pasture daily.

There is still doubt as to the advisability of attempting to " steam up " sows at farrowing time. What is more important is to get the bowels moving freely and the in-pig sow to have had exercise and green food daily during her pregnancy period.

Parturition should be interfered with as little as possible, but it may be a good plan to tie off the cords of the piglets and to remove their large canine teeth.

It is even more important for the sow to produce an adequate flow of milk, but this can be stemmed by the onset of (*a*) milk fever; or (*b*) parturient eclampsia; or by (*c*) psychological upsets; and (*d*) unknown causes. The first disease can often be treated with suitable preparations of calcium, whilst the second may respond to sulpha drugs or antibiotics, but in both diseases treatment should be applied immediately.

The flow of milk is governed mainly by hormones and a good blood supply to the udder—both of which may certainly be checked by mishandling or bad management at the time of farrowing. It is often a good plan to hand-massage the teats of the sow daily during pregnancy, as this creates a favourable response not unlike that which occurs when the newly-born piglets themselves nuzzle the teats. If the sow is particularly docile she will immediately lie down after being " conditioned " to this form of teat-massage—certain proof of its success as a psychological stimulant.

To avoid anæmia in the young piglets, chills must be avoided and iron salts supplied in a suitable form—although *earth* itself is rich in this element, containing ten times as much as barley, for example. If iron salts are to be given to the pigs *by mouth* they should be started on the third or fourth day after birth, and not later. The dose should be repeated each week for three weeks.

Chilling can best be avoided by giving attention first to the floor of the farrowing pen, and, if necessary, by provision of supplementary heat, i.e., infra-

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red ray lamps. These are cheap, and available either as the bright or dull emitter types, but even a hurricane lamp is better than nothing.

Castration is often effected by pedigree pig breeders as late as the eighth or ninth week, presumably because of their inability to select future boars at an earlier age. In such instances, unless particular care is taken, the wounds of the scrotum may become infected. This is due to the larger size of the incisions. These wounds may take several weeks to heal, and be associated with abscesses or infected blood clots. Therefore, it is best to castrate commercial stock as early as possible, and in America this operation is carried out in some districts as early as the fifth day of age.

Unless worms are seen to be voided in the manure, or there are other clear-cut symptoms, it is often quite unnecessary to de-worm young pigs, but it may be advisable on premises where they are known to occur regularly. The author prefers to use the sodium fluoride treatment—the drug being given dry and incorporated in the feed.

Weighing scales or a weighing machine are an absolute necessity on any progressive pig farm to-day. At three weeks the young piglets should weigh —if the sow is a good milker—from 11-14 lb. apiece, and if they are less than 10 lb. it suggests mismanagement or a bad sow. At weaning time, although the average weight for the country probably lies between 25 and 30 lb., many of the better breeders get their pigs to reach 35-40 lb. at eight weeks of age. Usually this can be accomplished only by creep feeding. i.e., the provision of a separate feed for the young piglets of high nutritive quality, and one so placed that the sow herself cannot reach it. It matters little whether it is in the form of mash or pellets, but in either case fresh water must be available *ad lib.* at the same time. Young pigs cannot satisfy their thirst by reverting to the mother's milk, for it is not available except following psychological stimulation, the initiation to which is, of course, the " mass " nuzzling of the teats by the whole litter. In consequence the quantity of milk obtainable from the teats on odd occasions and available to the single piglet is almost negligible. This is, of course, one reason why the runt pig can never thrive—he is pushed out from the main milk supply and there is none available for him when he gets the chance to get there himself.

Incidentally, whatever creep feed is used it should be continued until the pigs are at least 10 weeks of age—in this way the check at weaning time may be avoided.

At Stoke Mandeville we feed all our pigs from 10 weeks of age onwards on the dry meal, *ad lib.* system, the great advantage of which is that the pigs are fed to appetite, not only at meal times but throughout the full 24 hours of the day—they feed whenever they wish and for as long as they will, and, in fact, one often hears the feeders being used right through the night. But with

this system a free water supply is an absolute essential. In this feeding system the pigs may have a comparatively slow start, i.e., during the first week or 10 days, but they then go ahead most satisfactorily, and over the past two years our 800 pigs have averaged throughout the whole of their fattening period (from 44-200 lb. live-weight) 1.44 lb. per day. This offers a great contrast to the usual method of fattening, whereby the pigs are restricted to a maximum of 4 or 5 lb. of meal a day. In such circumstances it follows automatically that the pigs cannot put on more than 1-1¼ lb. a day (4 lb. feed for each 1 lb. live-weight gain), and, in fact, the average daily gain for such pigs generally reaches only 1.2 lb.

It is a most pleasing sight when one sees one's pigs thriving and putting on from 1½-2½ lb. a day in the later fattening stages. Naturally, some critics will wonder whether this rapid rate of growth is not associated with an excess of fat. All I can say is that over 90 per cent of all our pigs pass the present Educational Standard of grading, and I think it is fair comment to say that the bacon factory manager concerned considers our pigs to be amongst his best. Even in terms of the much stricter 1939 gradings, over 38 per cent of our pigs graded "A" throughout, i.e., in all three regions, loin, back, and shoulder, and only 9 per cent were "F."

One word of advice, however, where the *ad lib.* system of feeding is concerned. During the first week or so some pigs will scour, presumably from over-eating, but this can usually be checked quickly by closing the feed hoppers during the night, or, if necessary, during part of the day as well. Curiously enough other pigs, possibly even in the same pens, may show constipation, but I think this is mainly due to their failure to use the automatic water bowls sufficiently. The spring of the lip in any cattle water bowl (e.g., of the Fordham type) should be of the soft metal variety, so that the pigs can depress the lever with ease.

It is usually assumed that "diarrhœa" is an indication that some form of disease is present, but this is not necessarily the case. We have found that some of our better pigs have scoured for weeks on end, but during this time their weight gains have been above average. It is clear, therefore, that this form of diarrhœa is not of pathological significance. It may, perhaps, be due to the *ad lib.* system of feeding, and therefore possibly due to a higher than normal intake of mineral salts resulting in the production of a hypertonic solution in the intestines.

Everywhere evidence is accumulating that, all in all, it is the longer pigs which give leaner and therefore better carcasses. This maxim has been accepted in Denmark, where they have concentrated on length in their Landrace for many years; our own bacon factory managers concur, and most pig breeders are trying to get their Large White and Welsh carcasses as long as possible. In most instances this feature can be obtained often by breeding pigs with 15 or 16

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pairs of ribs. The following table gives proof that the better grading of bacon carcasses conforms to an increase in the number of pairs of ribs:—

ALL HOGS GRADED..

No. of pairs of ribs.	No. of pigs.	Length for weight.	Proportion of cuts.	Reduction of fat from shoulder to gammon.	Proportion of lean to fat.	Total marks per pig.
14	81	2.7	2.7	3.6	14.3	60.0
15	190	3.7	3.7	4.1	15.1	62.6
16	39	5.2	5.1	4.6	15.6	66.5

How can the practical pig breeder work to this end when he doesn't know the number of ribs in his pigs until they reach the bacon factory? Some farmers measure their pigs, from between the ears to the root of the tail, and the longer this measurement the better. Others insist that this measurement should be greater than that of the girth of the animal taken at a point opposite the first pair of teats—just behind the elbow. Recently it has been shown that an X-ray of pigs (before they are six weeks old) is a practical means of knowing just exactly the number of ribs present. The same procedure applied to pigs in the later stages of fattening also shows the depth of the back fat. In future we may find that X-rays can play a large part in the development of the pig industry.

THE ECOLOGY OF INFECTIOUS DISEASE

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In a report presented to the Medical Research Council, Topley and Wilson (1922) stress the need for a careful study of the factors determining the immunity of the herd as distinguished from that of the individual. They are here speaking particularly of controlled experiments upon bacterial infection among herds of mice, under laboratory conditions. In the field, it may be difficult to separate the resistance of the individual to infection by bacteria or viruses from that of the herd, since both are subject to those natural factors of their environment whose sum total makes up their ecology. Ecology may be defined as the study of an organism in relation to its environment. "From its earliest moment to its last," Borrodaile (1922) states, "the individual organism is directly acted upon by its immediate environment." In infectious disease there is a host-parasite relationship between cell and cell, or groups of cells. The host and the parasite cells are organisms dominated by their environment, but to provoke the clinical symptoms of disease it is usually necessary for the parasite to enter the host tissues, where its environment becomes artificial. Until such time as it gains access to the host it is subject to natural factors, but once within them its ecology becomes provided by the host proportionately to its degree of parasitisation, i.e., to its pathogenicity. The ecology of such pathogens as the *Mycobacterium*

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tuberculosis is largely, if not wholly, provided by the tissues its chooses for its predilection site. By contrast, saphrophytic organisms of low pathogenicity remain on the surface of the body or in situations where they are equally subject to natural factors and the influence of the host tissues. The host, however, remains exposed throughout the host-parasite relationship to all those natural factors, notably climate and topography, which bulk large in the ecology of all living organisms, whether they are parasitised or not, but whose influence may materially affect the degree of possible parasitisation.

Topography and climate are so closely linked as to be virtually inseparable. Markham (1947) has drawn attention to their combined influence upon infant mortality and the death rate, making the point that in the South of England the expectation of life is greater. The incidence of bovine tuberculosis is higher in the North of England (Topley and Wilson, 1948), and in 1875 Havilland commented upon the association of rheumatism (which may be bacterial in origin) with water-courses and valleys. Contours accelerate the transmission of water-borne infection. Thus the writer has encountered spread of *S. typhimurium* infection from one flock of ducks on a mountain stream to a second 200 yards downstream, whereas in a sluggish brook in East Anglia, sedimentation combined with biological activity reduced pollution by sewage to vanishing point within roughly the same distance (Gray, 1951). Contours also affect the movement of air. Cold air will flow downhill to form chilly reservoirs in the valleys. Lovell (1950) quotes Withers, who found that variability in temperature favoured losses in stock; March, for example, is notable for variations from mild to frosty weather, more hazardous for young stock than continued cold weather. Movement of cold air will enhance any effect of variable temperatures, and Brade-Birks (1944) quotes Dr. N. H. Pizer for the observation that cattle are encouraged to lie at night on high ground in a field because it is warmer in the cold hours.

Climate and topography also determine soil fertility. Climate especially is a dominant factor because it determines the great world groups of soil (Tansley, 1949), and movement of water imparted by contours assists to this end by the transport of soil. In the North of England the most fertile soils are typically found in the coastal belt and the river valleys. The *pH* of the soil of one Northumberland valley known to the writer was 7.5, in contrast to 4.5 on the hill-tops. The topography of a district and the mineral content of its soil are moulded by the surface geology. Farming practice is determined by climate and soil (Stamp, 1948), and these several factors of climate, topography, surface geology and farming practice, which are so closely interwoven as to be inextricable for practical purposes, are responsible for the abundance and the quality of the food available for man and his domesticated animals. If farming practice is excluded, they are responsible for the nutrition of wild life. The observation of Dr. Pizer that, owing to the movement of cold air, cattle favour high ground at night is of further interest in this connection, since he points out that as most of the droppings and urine are passed at night, those parts of a pasture are particularly enriched; and when the pasture is ploughed crops grown on the

higher ground are better in quality because of the accumulation of potash, phosphate and other plant nutrients. Buffalo and wild cattle, of course, will similarly influence the quality of savannahs and prairies. The quality and abundance of food are of the greatest importance in disease resistance. The classic experiments of Orr, Macleod and Mackie suggest that a definite correlation exists between ample pasturage, a high calcium and low phosphorus content of the blood, and sound health. Lovell and Hill (1940) have shown that there is a greater loss of calves in dairy herds in the spring, possibly associated with dietary deficiency in the mother during the winter months. Topley and Wilson (1948) emphasise, however, that as regards predisposition to infection by dietary deficiency, the one fact that stands out clearly is that a gross deficiency in vitamin A, especially during the period of rapid bodily growth, is associated with marked increase in susceptibility to infection. They quote Lassen (1930), who found that if rats were reared on a diet deficient in vitamin A their resistance was significantly lower to oral or parenteral administration of *S. typhimurium* than that of rats reared on a balanced diet, and the experimental trials by Mellanby, Green, and co-workers (1931) that provide evidence that relatively large amounts of vitamin A give women some protection against puerperal fever. Hawk, Oser and Summerson (1947) observe that "inanition accompanying severe vitamin A depletion may contribute in no small degree to lowered resistance to bacterial invasion," and further, that the milk of cows on green pasture is higher in vitamin A than that of stall-fed animals. On the Northumberland hill summits mentioned above, where the soil is acid, bent (*Nardus stricta*) and purple moor grass (*Moline cærula*) offer but poor, and seasonal, alternative grazing to the universal cocksfoot (*Dactylis glomerata*), whose carotene and vitamin A content is low (Moon, 1938). There are, moreover, well-defined belts of mineral deficiency.

There is another aspect of this combination of climate, topography, surface geology and farming practice (or its absence) which may be mentioned here. All may combine in the appearance of belts of insects that are possible vectors of infectious disease. Ewing (1942) states that the dipterous fly *Musca domestica* Linn. can carry *S. agalactiæ,* a common cause of mastitis of dairy cattle. The writer encountered a severe outbreak of "summer mastitis" due to this parasite, and involving half the cows in a herd, associated with swarms of the dipterous *Hydrotea irritans,* possessing a soft proboscis to suck up moisture, and which appeared in clouds after some days of very humid weather at a time when the cows were turned out from dawn to dusk in old permanent pasture whose dense mat favoured ecdysis of insects.

Yet although it is accepted that good nutrition is an essential weapon of resistance, the writer found in Northumberland that the hill cattle that wandered, at times half-starved, over bleak slopes exposed to the vagaries of a severe climate, suffered less from microbial parasitisation than the well-fed and sheltered herds of the valleys. Infection with *Brucella abortus* affected between 30-50 per cent of the farms in the valleys and the coastal belt, but in the hill farms

the incidence was low and sporadic. The incidence of mastitis due to *S. agalactiæ* decreased with altitude. Herds were encountered in the valleys and the coastal belt with an incidence as high as 50-80 per cent, but during the two years 1943 and 1944 only isolated cases were met on the hills.

This curious absence of infection by *Brucella abortus* and *S. agalactiæ* among hill cattle as compared with those of the valleys he attributed to the domestication of the latter and associated undesirable practices of animal husbandry. When animals are crowded together in numbers (and the valley farms supported more head of stock per acre) the risk of infection rose proportionately. Most of the valley farms practised machine milking, but not those of the hills, and Watts (1942) has pointed out the association of machine milking with mastitis due to *S. agalactiæ*. It would be interesting to know whether the greater incidence of bovine tuberculosis in North Britain (Topley and Wilson, 1948) occurs, as the writer suspects, not so much among hill cattle, half-starved as they may be but living under conditions approaching the wild or feral state, as in the valley cattle exposed to the same harsh climate and crowded periodically into buildings, to suffer those pernicious vagaries of temperature commented upon by Withers (Lovell, 1950) which complicate increased risk of infection by over-crowding. This conclusion is supported by the observations of Villemin (1868), quoted by Topley and Wilson (1948). Villemin noted that whereas tuberculosis was common among troops living in barracks, it was uncommon among troops in the field, and that among the Allied Armies before Sevastopol during the bleak winter of 1854-1855, although they were living under most unhygienic conditions, subject to poor food, severe cold, and excessive fatigue, cases of tuberculosis were very rare.

Turning to the parasite, it is found to be the sport of identical factors of climate and soil, whether natural or provided by the host tissues. An extensive study of the naso-pharyngeal bacterial flora of different groups of persons in London and S.E. England showed that there was a seasonal trend, the general carrier rate tending to fall at any season in association with increasing sunshine and decreasing relative humidity (Lovell, 1950). The same writer also observes that outbreaks of toxæmia in sheep due to *Cl. Welchii* type D frequently follow transfer to a flock from one type of pasture to another, and their return coincides with cessation of cases of the disease; is there, he asks, some substance in the diet of the pasture which facilitates propagation of the Clostridia?

The existing physical conditions of the soil as represented by the host tissues may be inhibitory. The parasite of mammalian tuberculosis cannot colonise cold-blooded animals; the frog resists the anthrax parasite if it is kept at 18 degrees, although it succumbs if kept at 30 degrees (Preisz, 1909, quoted by Topley and Wilson, 1948). The *pH* of the skin is acid and the acidity is increased by sweating, as in the hyperæmia of surface infection; the *pH* of the gastric contents is acid from free hydrochloric acid, and acids that freely dissociate, such as hydrochloric, are more powerful antiseptics than those that do not (Browning and Mackie, 1949).

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The nutrition provided by the host soil may be unsatisfactory; the frequent absence of *S. agalactiæ* from cases of mastitis in hill cattle encountered by the writer may be associated with low protein intake by the host and low protein content of the milk, for Davis and Mattick (1936) state that the condition and concentration of protein foodstuffs is one of the most important factors controlling the microflora of milk.

Furthermore, the parasite is generally exposed to biological competition. It is only one member of a mixed microflora inhabiting the host tissues, and with whose other members it has to struggle for existence. Simple changes in the diet of the host cause shifts in the microflora of the gut, and in the ruminant may be responsible for profound disturbances in the rumen microflora and also the microfauna. Tosic and Mitchell (1948) observe that in sheep the cobalt content of the microbial population of the rumen is related to cobalt concentration in the diet, symptoms of cobalt deficiency in the host being due to a cobalt deficiency in the rumen bacteria. The metabolism of the parasite may defeat its own ends, as in the synthesis of vitamin K by *Escherichia coli* in the gut (Hawk, Oser, and Summerson, 1947), which is utilised by the host.

The supreme importance of the ecology of the host appears when the pathogenicity of the parasite is such that it seeks the interior of the host tissues. Except as a result of trauma, all such parasites are first opposed by the epithelium lining the natural orifices of the body and the channels that lead from them. But epithelial tone, i.e., its resistance, is lost when the diet is deficient, in vitamin A especially. A similar distinction can be drawn in plant pathology between wound parasites, e.g., the *Pseudomonas* responsible for halo-blight of beans, and vascular parasites, e.g., the *Corynebacterium* responsible for bacterial tomato canker, although as in animal pathology a wound parasite of plants may later invade the vascular system.

The efforts of a parasite to colonise the deeper tissues of the animal host may be met by an increased production of humoral antibodies or by the agents of cellular immunity, the fixed or wandering histiocytes that are often phagocytic and ingest the parasite. The response of either system is usually excessive, presenting an example of Weigert's Law that the degree of reparation of injured tissue exceeds the demand. Topley and Wilson (1948) suggest that humoral immunity is probably always subsidiary to the phagocytic mechanism and is seldom, if ever, the main factor in defence.

There is nothing comparable to phagocytosis in plant immunology, but the chemical agglutination of soft rot bacteria (Berridge, 1926), extended by the writer to other plant pathogens, suggests that in the sap of living plants the spread of pathogenic organisms may be inhibited by physical factors.

In the animal kingdom, however, phagocytosis can be traced right down the scale. The writer has witnessed the activity of phagocytes in insect vectors of watermark disease of willows, a parasitisation by the *Bacterium Salicis* Day (Gray, 1942), there are leucocytes in crustacea and molluscs (Bisset, 1947), and

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the writer has noted the solitary leucocyte of the earthworm *Lumbricus terrestris* (Dakin, 1928) ingesting a bacterium in the cœlomic fluid. Bisset (1947) points out that in the study of invertebrate immunity, emphasis has been laid on the importance of phagocytosis, but that nevertheless the production of humoral antibodies appears to be almost universal in the animal kingdom. Both mechanisms, however, are of great interest to an ecologist in so far as their precursors may be traced in kind in the association of bacteria and protozoa in natural soil. Here the ingestion of soil bacteria by soil protozoa is a familiar feature (Anscombe and Singh, 1948). During a recent investigation by the writer, he observed that in a stream polluted by sewage the abundance of bacteria-eating ciliates was directly related to the abundance of fæcal coliform bacteria, while in a second stream not polluted by sewage a similar abundance of bacteria-eating ciliates followed pollution of the stream by soil (Gray, 1951). Moreover, the ciliates showed a selectivity for certain bacteria according to their reaction to Gram's stain that proved to be statistically significant (Gray, 1951), and an identical selectivity by four species of soil amœbæ is reported by Anscombe and Singh (1948). This general multiplication in nature of bacterial predators subsequent to pollution, and the selectivity shown by certain predators for particular bacteria, is closely paralleled in infectious disease by the multiplication of phagocytes following parasitisation of a susceptible host, or the association seen in the farm animal of the polymorph leucocyte with pyogenic infections or the lymphocyte with infection by the mycobacterium of tuberculosis. In natural soil, Singh (1946) has shown that there are soil bacteria whose excretions are inhibitory to soil protozoa, while others attract them; indeed, the general interplay between soil bacteria and bacteria-eating protozoa largely depend upon chemotactic factors that parallel, for example, the agressin production and opsonic index that figure so prominently in humoral immunity of the mammal. The especial point of interest to the ecologist is that not only is there such a close analogy between these inter-cell reactions of infectious disease and those found in nature, but that both are swayed by identical physical factors, notably the reaction of the soil (whether natural or provided by the host tissues) and temperature.

In conclusion, it is suggested that under natural conditions, i.e., in the field, the host - parasite relation of infectious disease may be considered from two aspects. There is, first, the environment of the host. All those factors of climate, soil, nutrition and civilisation that make up its environment should be carefully scrutinised. When their respective values have been weighed, the extent of parasitisation can largely be foretold.

For the ecology of the parasite is the product of the same factors, either acting upon the parasite directly, or, when the host-parasite relation has been established, through the medium of the host tissues, viz., climate (temperature and moisture), food, and civilisation (overcrowding) as represented by competition with other micro-organisms or host tissues not directly responsible for humoral or cellular resistance.

Secondly, when the latter mechanisms are provoked by penetration of the

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parasite into the host tissues, a biological reaction is witnessed which although an integral part of the host and modified by the complexity of its structure, is fundamentally a reaction between two cells that can be traced through the animal kingdom from unicellular organisms, through the simpler metazoa, to the mammal, e.g., the farm animal. Although this interaction is complicated in the mammal by the great organisation of its tissues, nevertheless it is subject to the same ecological influences that affect the interactions of single cells in nature. And these are the identical factors that dominate the ecology of the host, or the parasite, or any association between them.

It was originally suggested that from an ecological aspect the individual and the herd might be considered as one unit. This is most true of farm animals, for their environment is semi-artificial (although ultimately imposed by natural conditions of climate and soil), and flocks and herds ideally receive the same quality foods and the same husbandry. Except on pasture, there is little opportunity for an individual to profit at the expense of its neighbours, and even were it so, cropping should ensure a uniform quality of the herbage. A balance of uniformity is preserved. Careful breeding starts the young at a common level of health, and throughout their lives farm animals are virtually under control conditions. Individuals are cut to a pattern by the artificial or semi-artificial environment, and the herd therefore is only a collection of individuals subject to the same ecological factors as a single individual.

But the balance of uniformity is lost when, as on hill farms, young stock wander at will and build up their own constitutions, profiting when they find patches of good grazing. Or, on the other hand, when animals are intensively reared, proportionately increasing the dangers to the susceptible host at risk. Battery brooders for poultry, however attractive economically, cannot but be condemned by an ecologist. Housing may be beneficial in intent, as when calves that have been turned out to pasture during the summer months are brought in at night from September or October onwards and given a foddering of hay, treatment especially desirable where Strongylosis of the trachea and bronchi is prevalent and predisposes to microbial parasitisation of the upper respiratory passages.

However, although the wild animal is not immune to microbial parasitisation, and may suffer from any of the ecological factors discussed above which predispose to such parasitisation, while the individual may succumb, the race can survive by roaming to fresh pastures. The farm animal, however, is penned within the farm boundaries, however severe the natural features determining the practice of the farm.

Smith (1951) has stressed the vital importance of the evolutionary approach to problems of infection, emphasising that, in common with all life, bacteria and viruses are extremely flexible in their reactions to their environment. He points out that Bruce-White concluded that the *Salmonella,* for example, must have had a common ancestor. The scores of species now recognised have adapted

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themselves to a wide range of hosts, that is, to an ecology distinct from that of the parent form. Evolution, however, is only a convenient label for the unstable end-products of processes initiated and controlled by the environment of the organism, that is, of its ecology. Compared with the time-scale of the evolution of man, about three months, Smith (1951) suggests, are required for the evolutionary history of an infectious organism. In any outbreak of infectious disease it might well prove of immense value to consider all those ecological factors summarised above, aberrent symptoms indicating perhaps that a departure from the normal ecology of the host had induced evolutionary changes in the parasite. In brief, to reorientate our outlook so that the host-parasite relation of infectious disease falls into line with similar phenomena and becomes a subject for general biological enquiry.

The Ministry of Agriculture, acting on recommendation from the Agricultural Improvement Council and the Agricultural Research Council, set up in 1950 within the framework of the National Agricultural Advisory Service a series of experimental farms distributed on the basis of soil and climate to study crop and animal husbandry under differing environmental conditions. These farms will certainly provide in course of time most valuable data on animal husbandry that would be equally valuable to the epidemiologist who approaches his subject from the ecological aspect of the factors determining herd immunity.

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NECROTISING ENCEPHALOMYELITIS OF GOATS IN CEYLON (ENCEPHALOMALACIA OF GOATS, GOAT PARALYSIS)

A Note on the Occurrence of Mematode Larvæ in the Brain and Spinal Cord

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THE condition known as "goat paralysis" or "lumbar paralysis" of goats in Ceylon was described by Crawford (1939-42); further observations were made by Malkani and Pillai (1950). Innes (1951) was asked to make histological examination of brains and spinal cords from eight affected goats, autopsied in Ceylon; the material was fixed in 10 per cent formalin saline and sent to a laboratory in the U.S.A. where Innes was working. He found no abnormalities in four of the specimens, but very pronounced lesions of a necrotising encephalomyelitis in the other four cases, a condition which he had not encountered in any of the diseases of the nervous system of animals previously studied. In his search of the literature, Innes found the publications of Yamagiwa, Shoho and Tanaka (1941-47), and was able to obtain sections of the brain and spinal cord from goats affected with "paralysis" in Japan. He found that this latter condition was also a necrotising encephalomyelitis. As the Japanese workers claimed that the disease is caused by the invasion of *Setaria digitata* larvæ, Innes re-examined the Ceylon material, but was unable to detect any larvæ. However, he pointed out that the Japanese authors had stressed that often only one, two or three larvæ could be found even in fresh material. In a private communication to the present writer, he advised that a very careful search of the whole brain and cord from fresh acute cases should be made. Recently, two such cases were available for autopsy. The purpose of this note is to record that nematode larvæ were found in the nerve tissue of both cases.

Case 1.—Jumnapari female, 2 years, born in Ceylon. History of an attack of paralysis some weeks previously; had been treated. Complete paralysis ensued on October 1, 1951; animal received on October 4, 1951. Euthanasia on October 9, 1951. Complete collapse; hind legs stiff, little or no evidence of sensation in the hind inter-digital space, fore legs flexible, sensation in fore inter-digital space. Good appetite, in fair condition, temperature normal, eyes bright and intelligent. The animal was bled from the jugular; the brain and spinal cord exposed; over 10 c.c. of water-clear cerebro-spinal fluid was removed in a hypodermic syringe; this was examined immediately, but no parasites were found. Examination of the faint deposit after centrifugation disclosed only a few lymphocytes. The blood-vessels of the meninges over the central fissure were engorged, the brain was rather firm and yellowish in colour. The peridural tissue of the spinal cord was composed chiefly of yellowish fatty material. There were no obvious abnormalities of the cord.

Some portions of the cord and brain at different levels were removed for fixation. The remainder of the cord was minced with scissors, mixed with about 100 c.c. of sterile broth and put in the refrigerator for two hours. The sus-

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pension was then filtered through four layers of coarse gauze and the filtrate centrifuged for 10 minutes at 3,000 r.p.m. About 30 samples of the deposit were examined microscopically; in one sample only an incomplete nematode larva (tail end) was found. The brain was similarly treated and examined, but without success; the unfiltered mush of tissue was treated with pancreatic extract and incubated at 37 degrees Centrigrade for 15 hours, then centrifuged and the deposit examined, again without success.

Case 2.—Jumnapari female stud goat, aged 2 years; ataxia, hind legs wobbled and crossed each other when the animal was made to walk. Good appetite, temperature normal. Euthanasia by bleeding from the jugular on October 11, 1951. Only 2 c.c. of cerebro-spinal fluid mixed with blood obtained, no parasites found. The brain and cord showed no gross abnormalities. The cord was cut in thin slices with a safety-razor blade in sections of about one inch at a time; both sides of each slice were carefully examined for minute lesions. Several small foci of softening were found in the dorso-lateral column, and in one there was an incomplete larva.

About the level of the last dorsal vertebra in the same column there was a brownish nodule about one millimetre in diameter, very firm, gritty when pressed on the slide. On microscopic examination, broken down nervous tissue mixed with capillaries, blood cells and crystalline structure were seen; no parasites were detected.

The brain was similarly sliced and examined. In the white matter of the cerebrum, just behind the cruciate sulcus and near the surface, there were several small cavities lined with pinkish, crumbly material; a microscopic examination disclosed only broken down nerve tissue. A little deeper, there were three or four minute foci of softening, and in these were found one complete larva (Figs. 1 and 2) and three incomplete (tail only) larvæ. The complete larva measured 800 μ long, 20 μ thick at the head and 15 μ in the middle. There was some cell debris adhering to the parasite. In the posterior third of this complete specimen and of the incomplete larvæ, there was a cylindrical body about 60 μ long, and contiguous with the inner wall of the nematode. Nearer the tail there was a spherical, refractile body about 10 μ in diameter. Soon after removal from the nerve tissue, these objects disintegrated or disappeared.

The mouth appeared to have three lobes of thickened cuticle surrounding it; the tail was pointed and straight.

Discussion

Two affected animals only have been examined, but in both, nematode larvæ have been found. In the case with inco-ordination of the hind legs the larvæ were found near the centre for the legs. This result fulfils the prediction made by Innes. Further cases will be examined, but it would appear that goat paralysis is not as common as it was some years ago. It is a matter of speculation whether this is due to the widespread use of D.D.T. and other insecticides which have reduced the numbers of vectors, or whether it is some other explanation. Further work is in progress. Meanwhile, it may be mentioned that a publication

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by Bush (1951) appeared soon after the communication by Innes. Bush gave a brief review of the disease termed "lumbar paralysis" in Japan, and states that all his attempts to reproduce the disease by the inoculation of microfilaria of *Setaria digitata* obtained from mosquitoes (*Ædes togoi*) were unsuccessful. He states that the claims made by the Japanese workers in Korea were never reproduced in Japan, and he concludes that the chief cause of "lumbar paralysis" of goats, sheep and other animals in Japan is anæmia and osteomalacia resulting from malnutrition and mineral deficiency. Here it may be remarked that Innes found no lesions in the brains and cords of four of the eight specimens sent to him from Ceylon, and he states: "There are pointers that the 'lumbar paralysis' might be easily confused clinically with maladies in which the animals might be unable to rise and walk, but which might not represent neuro-paralysis."

Summary

Nematode larvæ were found in the brain and spinal cord in two cases of "goat paralysis" in Ceylon.

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STUDIES ON THE ABNORMAL SPERMATOZOA OF BULL SEMEN—III.

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(B) *Relationship of abnormal sperm to fertility rate*

A proportion of sperm differing from the normal can be found in the semen of all animals. In Section D we have shown the relative incidence of these abnormal forms in two groups—normal bulls and abnormal bulls. The semen characteristics of the abnormal groups have then been examined, according to the fertility levels, in six groups. Table XIII shows the average percentage occurrence of the main parts of the sperm in these groups. It will

be seen from this table that the normal semen contains the lowest percentage, and that there is a steady increase through the first two groups of infertile semen. In the lowest of the infertile groups, while the head abnormalities remain at the same level as the previous group, the abnormalities of the middle piece show a distinct drop. Bulls suffering from acquired sterility have one of the highest levels of abnormal heads, but again a fall in the middle piece abnormalities is evident. Bulls born sterile predominantly show a high level of middle piece abnormalities. This figure, however, has been influenced to a marked extent by one bull (ABR 15), and must be taken with reserve.

TABLE XIII

	Ejaculate	Heads	Tailless heads	Middle pieces	Headless tails	Tails
Fertile bulls—	One	2.97	1.57	8.31	0.35	0.19
	Two	3.30	1.04	6.68	0.33	0.38
	Three	2.75	3.08	5.66	0.91	0.50
Infertile 41 per cent	One	5.55	4.10	14.21	3.44	0.55
and over—	Two	7.11	5.99	13.33	1.88	0.77
Infertile 21 per cent	One	10.75	1.08	18.75	0.33	0.16
to 40 per cent—	Two	8.99	0.40	14.66	0.40	0.26
	Three	5.33	2.66	16.16	0.49	0.83
Infertile 4 per cent	One	7.62	1.74	10.33	0.99	0.33
to 20 per cent—	Two	8.04	3.80	8.61	0.38	0.57
	Three	5.49	2.66	6.83	0.66	0.00
Sterile bulls	One	9.59	1.66	11.19	1.00	0.33
(acquired)—	Two	9.86	2.53	7.46	1.53	0.07
	Three	5.55	1.66	7.21	1.00	0.22
Sterile bulls	One	5.87	0.25	25.33	0.41	0.25
(congenital)—	Two	5.75	2.33	19.16	0.75	0.50
	Three	4.75	0.58	36.99	0.66	0.33

In considering the group of fertile (normal) bulls, by far the greater proportion of all samples examined have the smallest percentage of abnormals. In abnormal head, the figures were as follows:—

Ei	10/14 (71.6 per cent)	Showed less than 3 per cent abnormal forms.
	5/14 (35.7 per cent)	Showed no tailless heads at all.
	4/14 (28.6 per cent)	Showed less than 1 per cent tailless heads.
Eii	8/15 (53.3 per cent)	Showed less than 3 per cent abnormal forms.
	3/15 (20.0 per cent)	Showed between 3 and 4 per cent abnormal forms.
	5/15 (33.3 per cent)	Showed no tailless heads at all.
	4/15 (26.2 per cent)	Showed less than 1 per cent tailless heads.
Eiii	3/4 (75.0 per cent)	Showed less than 1 per cent abnormal forms.
	1/4 (25.0 per cent)	Showed less than 1 per cent tailless heads.
	1/4 (25.0 per cent)	Showed between 2 and 3 per cent tailless heads.

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Similarly, the middle piece figures were:—

Ei	6/14 (42.9 per cent)	Showed less than 5 per cent abnormal forms.
	5/14 (35.7 per cent)	Showed between 5 and 10 per cent abnormal forms.
Eii	6/15 (40.0 per cent)	Showed less than 5 per cent abnormal forms.
	7/15 (46.6 per cent)	Showed between 5 and 10 per cent abnormal forms.
Eiii	2/4 (50.0 per cent)	Showed less than 5 per cent abnormal forms.
	2/4 (50.0 per cent)	Showed between 5 and 10 per cent abnormal forms.

Within this fertile semen group, a small number of bulls having very good fertility rates have been sub-divided. The figures for these bulls are given in Table XIV.

TABLE XIV

Bull	Fertility rate per cent	Head abnormalities		Tailless heads		Middle piece abnormalities		
		Ei	Eii	Ei	Eii	Ei	Eii	Eiii
N 4	84.0	1.33	0.66	2.3	—	1.66	1.33	—
23	83.0	0.66	2.0	—	1.6	3.33	19.66	—
29	80.0	1.66	2.0	—	—	19.33	3.33	—
31	96.0	—	2.0	—	0.6	—	5.33	3.33
37	70.0	2.66	4.33	—	0.3	4.10	8.33	—
Average	82.6	1.58	2.15	2.3	0.83	7.10	7.59	3.33

In the case of the two bulls N 23, and 29, showing 19.66 per cent and 19.33 per cent respectively, each high figure was caused by sperm having attached pale staining protoplasmic drops. (Immature sperm of Lagerlof, 1934.) If these are excluded and only other types of abnormals counted (2 per cent and 1 per cent respectively), then the averages for the middle piece abnormals become 2.5 per cent for the first ejaculate and 3.8 per cent for the second ejaculate. Both these animals were young bulls, 23 being 2 years, 29 being 1½ years, and so were not fully mature. Tail abnormalities have also appeared in least numbers in the greater proportion of fertile ejaculates thus:—

Ei	8/14 (57.1 per cent)	Showed no tail abnormality.
	5/14 (35.7 per cent)	Showed less than 1 per cent abnormal tails.
	6/14 (42.9 per cent)	Showed no headless tails.
	5/14 (35.7 per cent)	Showed less than 0.33 per cent headless tails.
Eii	6/15 (40.0 per cent)	Showed no tail abnormality.
	4/15 (26.6 per cent)	Ejaculates showed less than 0.33 per cent tail abnormality.
	7/15 (46.6 per cent)	Ejaculates showed no headless tails.
	4/15 (26.6 per cent)	Ejaculates showed less than 0.33 per cent headless tails.

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Eiii 1/4 (25.0 per cent) Ejaculates showed no tail abnormality.
2/4 (50.0 per cent) Ejaculates showed less than 0.33 per cent tail abnormality.
1/4 (25.0 per cent) Ejaculates showed no headless tails.
1/4 (25.0 per cent) Ejaculates showed less than 0.33 per cent tail abnormality.

TABLE XV—HEAD ABNORMALITIES

TABLE XVI MIDDLE PIECE ABNORMALITIES

	NECK			Middle Pieces Minus Protoplasmic Drops															Middle Pieces With Attached Protoplasmic Drops							
	-			BENT			SWOLLEN			KINKED									BENT			SWOLLEN			KINKED	-	
	S	K	N	A	M	P	A	M	P	A	M	P	C	D	S	T	O	A	M	P	A	M	P	M	P	C	D
No of Ejaculates	1/16	9/16	3/16	2/16	15/16	8/16	9/16	3/16	5/16	1/16	1/16	-	11/16	5/16	5/16	9/16	5/16	1/16	9/16	4/16	9/16	3/16	9/16	1/16	-	1/16	1/16
Per Cent	6·2	56·2	18·7	12·5	93·7	50·0	56·2	18·7	31·2	6·2	6·2	-	68·5	31·2	31·2	56·2	31·2	6·2	56·2	43·7	56·2	18·7	56·2	6·2	-	6·2	6·2
Occurrence	1·0	2·8	1·0	1·0	11·7	11·2	8·7	2·0	1·8	1·0	2·0	-	3·3	1·0	1·0	2·0	1·2	2·0	17·0	6·8	2·3	1·3	8·1	1·0	-	1·0	1·0
No of Ejaculates	-	2/3	-	-	3/3	2/3	2/3	-	1/3	-	-	-	3/3	1/3	1/3	2/3	-	-	2/3	2/3	2/3	1/3	2/3	-	-	-	-
Per Cent	-	66·7	-	-	100·0	66·6	66·6	-	33·3	-	-	-	100·0	33·3	33·3	66·7	-	-	66·7	66·6	66·6	33·3	100·0	-	-	-	-
Occurrence	-	3·5	-	-	13·7	20·0	6·5	-	1·0	-	-	-	14·7	7·0	1·0	2·5	-	-	8·5	9·5	6·0	1·0	1·0	-	-	-	-
No of Ejaculates	-	2/5	-	1/5	4/5	1/5	1/5	1/5	-	-	1/5	-	3/5	1/5	2/5	1/5	2/5	1/5	2/5	3/5	1/5	-	3/5	-	-	-	-
Per Cent	-	40	-	20·0	80·0	20·0	20·0	20·0	-	-	20·0	-	60·0	20·0	40·0	20·0	60·0	20·0	60·0	40·0	20·0	-	40·0	-	-	-	-
Occurrance	-	3·5	-	37·0	46·5	1·0	83·0	1·0	-	-	2·0	-	10·3	1·0	1·5	22·2	2·5	6·0	27·3	29·5	1·0	-	1·0	-	-	-	-
No. of Ejaculates	-	5/9	-	-	6/9	8/9	4/9	2/9	4/9	-	-	-	3/9	-	-	4/9	5/9	-	4/9	7/9	4/9	2/9	5/9	-	-	1/9	-
Per Cent	-	55·5	-	-	66·7	88·8	44·4	22·2	66·7	-	-	-	100	-	-	44·4	55·5	-	66·7	77·8	44·4	22·2	55·5	-	11·1	-	-
Occurrences	-	2·0	-	-	5·7	8·7	4·7	2·5	5·6	-	-	-	1·8	-	-	4·0	2·2	-	6·5	10·0	2·4	1·0	2·50	-	1·0	-	
No. of Ejaculates	1/6	3/6	1/6	1/6	5/6	6/6	1/6	-	3/6	-	-	-	5/6	-	3/6	2/6	3/6	-	2/6	3/6	3/6	-	2/6	-	-	-	-
Per Cent	16·7	50·0	16·7	16·7	83·3	100	16·7	-	50·0	-	-	-	83·3	-	50	33·3	50·	-	33·3	83·3	50·	-	33·3	-	-	-	-
Occurrences	1·0	2·7	1·0	12·0	3·8	16·7	4·0	-	3·33	-	-	-	4·6	-	1·0	8·5	1·7	-	2·0	17·0	2·3	-	5·0	-	-	-	-
No of Ejaculates	-	4/5	1/5	1/5	2/5	3/5	4/6	1/4	-	-	1/4	-	5/5	-	2/5	4/5	1·5	-	1/5	1/5	1/5	-	1/5	-	-	-	-
Per cent	-	80·0	20·0	20·0	40·0	60·0	80·0	25·0	-	-	25·0	-	100	-	40	80·0	20·	-	20·0	20·0	20·	-	20·0	-	-	-	-
Occurrences	-	4·2	1·0	80	72	26·7	33·0	1·0	-	-	1·0	-	66·4	-	1·7	6·7	1·0	-	13·0	1·0	5·0	-	1·0	-	-	-	-

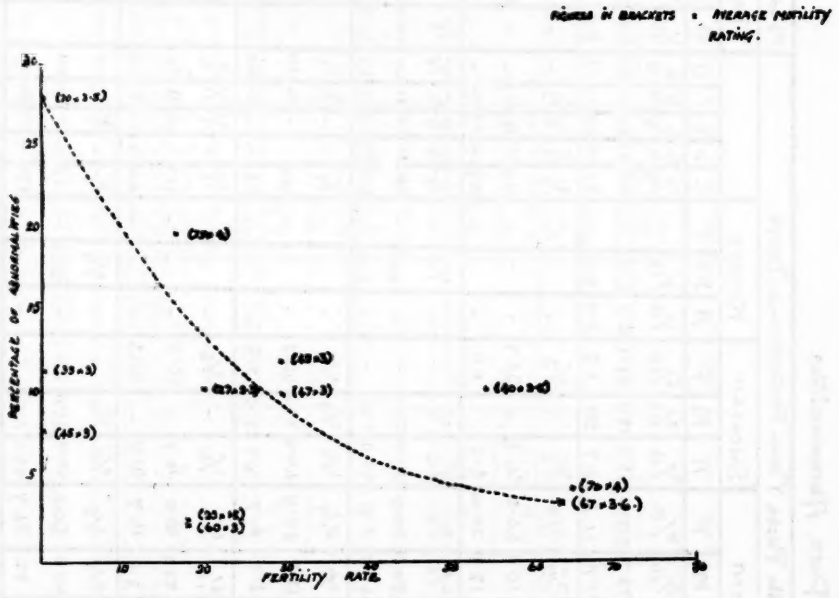
The same general trend can be shown for each of the abnormal groups in turn.

The various types of abnormal sperm in each of the groups have been compared on the basis of the number of bulls showing the various types, and of their average occurrence. The combined results of this comparison are given in Tables XV (Head Abnormalities) and XVI (Middle Piece Abnormalities).

(i) Head abnormalities. (See Diagram III).—In considering these abnormalities, the first important finding is that any type of abnormality can on occasion be found in otherwise excellent semen. The proportion of bulls

DIAGRAM III

THE RELATIONSHIP OF HEAD ABNORMALITIES TO FERTILITY



showing such types (e.g., double heads) is low; and the numbers of such abnormals are also low. Occasional single sperm of any type are of no significance and these give fertile semen a normal range of variants in measurement studies.

When the occurence of various types of head abnormals increases moderately, or when one single type is increased to a greater extent, then fertility is reduced. Thus, in our investigation one bull (ABR 33), having 25 per cent to 30 per cent normal-staining, normal-size narrow heads, proved completely sterile in spite of moderate numbers and motility after trial on two farms with known fertile cows. Another case (ABR 22), having between 3 per cent and 5 per cent double heads, had an over-all fertility rate of 20 per cent.

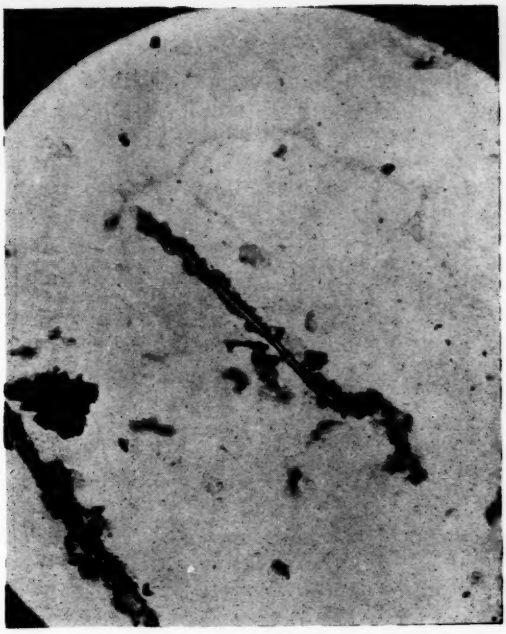


FIG. 1
Nematode larva from cerebrum of goat. × 56.

FIG. 2
Larva from cerebrum of goat. Head, × 266.

(*Article by McGaughey, page* 449)

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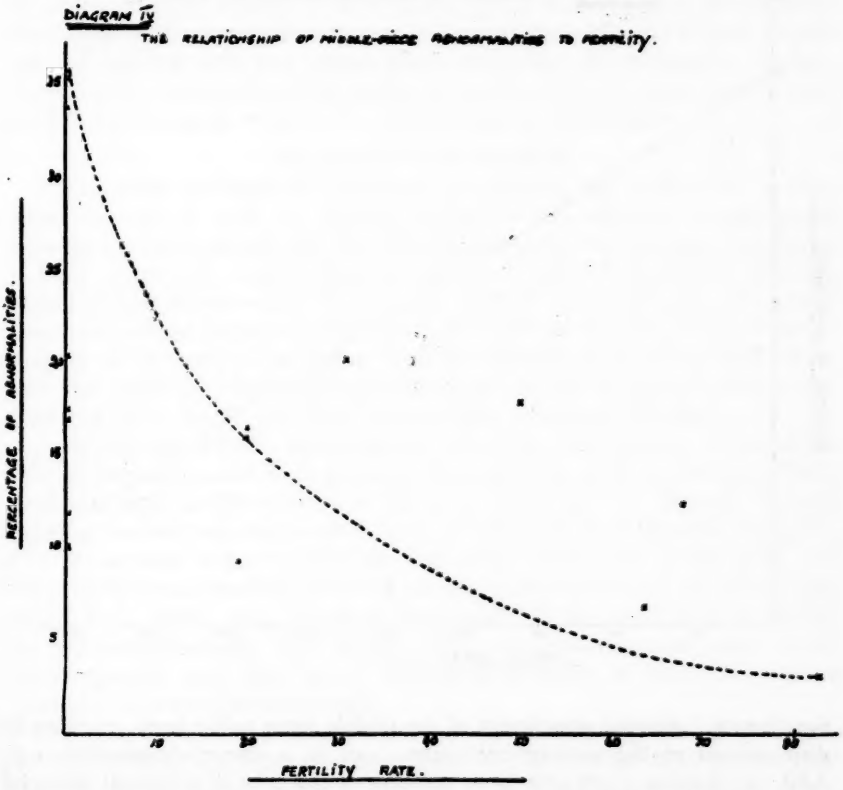
Abnormalities of the *Galea capitis* are of great importance, and they occurred in a high proportion of the infertile and sterile groups. One case (ABR 27), having 5 per cent abnormal *Galea capitis*, was completely sterile. Any bull consistently showing abnormality in this part of the head at a level of 1 per cent or more is likely to be infertile.

The relationship between percentage of abnormal sperm heads and fertility rates of the bulls is shown in Diagram III. The motility at collection

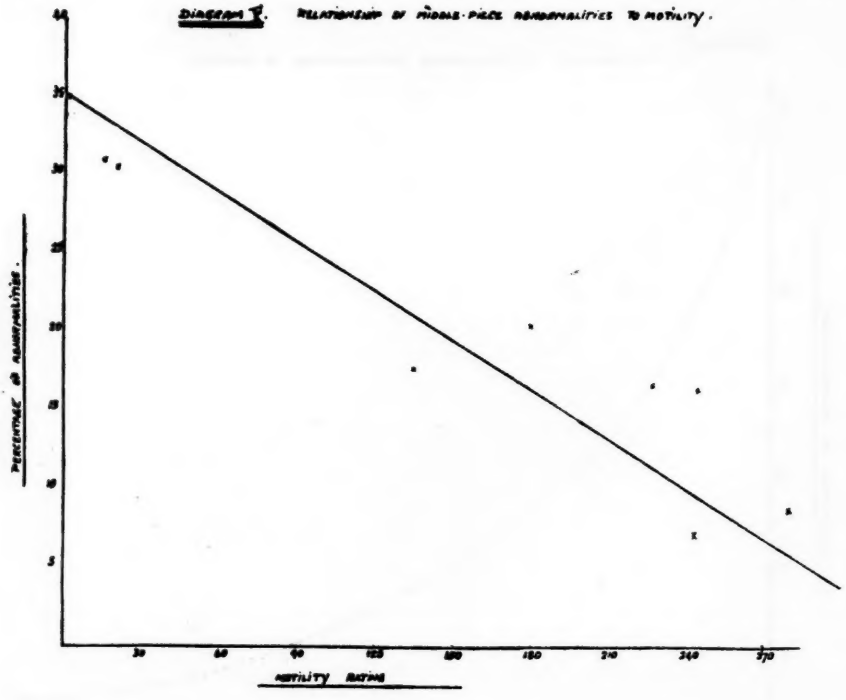


(average of all ejaculates) is in brackets against each bull plotted. The two greatest percentages of abnormal heads were made up of elongated heads, while one of the other sterile bulls showed abnormality of the *Galea capitis*.

(ii) Middle piece abnormalities. (See Diagram IV).—First ejaculates in general contain a greater percentage of abnormal middle pieces than subsequent ejaculates. The cases at the writer's disposal have not a sufficient spread of sexual rest periods to be compared with the series of Trimburger and Davis (1942), who stated that the greatest numbers of abnormal sperm occurred in the semen of normal bulls between 20 and 30 days after the last service.

Abnormalities of the middle piece adversely affect fertility either by the lack of constant, good motility (poor longevity) or by the mechanical obstruction of large proportions of abnormal, poorly motile types. This latter is one factor which adversely affects motility in first ejaculates (preputial cells also interfere). (See Diagram V.)

Thickened or swollen middle pieces appear to the writer to be of great



significance. Abaxial attachment of the middle piece to the head, resulting in displacement of the anterior centrosome, can be a severe abnormality—e.g., ABR 12, showing 7 per cent to 10 per cent of this type of abnormal, dropped from a good fertility rate to 20 per cent over-all fertility.

Next in importance are coiled middle pieces (Fig. 19); these are frequently seen in conjunction with other abnormalities in bulls of low fertility —e.g., ABR 15 and ABR 21. One per cent or above of this type is significant.

Bends of the middle piece being of more frequent occurrence, great numbers may be present before the fertility rate is affected; 3 per cent would arouse suspicion, while 10 per cent would affect the fertility rate.

Sperm with protoplasmic drops attached to the middle piece may be increased in number in the mid-infertile groups; but at low levels of fertility,

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and in cases of sterility, their number tends to be reduced. This may be linked with the marked fall in numbers between ejaculates, seen at these levels of fertility, arising from disturbed spermatogenesis.

(iii) Abnormalities of the sperm tail.—These occur rarely *per se*, and when they do occur the numbers are small. In the present investigation, differences have been so small that recommendations cannot be made. Coiling of the tail arising during maturation of the sperm is the principal type met with.

(iv) Headless tails and tailless heads.—These occur slightly more frequently in abnormal bulls' semen. The variation which has existed in the levels of these types in this investigation points, in the writer's opinion, to a great proportion of headless tails and tailless heads being due to mechanical damage. Undoubtedly, when either abnormality is present to a very great extent, then sterility will result, as is shown in Guernsey sperm decapitation.

(E) Origin of Abnormalities

The mode of origin of abnormal spermatozoa has evoked few studies. After the pioneer work of Lagerlof (1934) in demonstrating a relationship between the semen picture and the testis histology, until the tentative suggestions of Haq (1948) little definite progress has been made. Branton and Salisbury (1946) studied smears made from various levels of the epididymis and showed that there was no statistically significant difference in the percentage of abnormalities of the head of the sperm from the different parts of the epididymis; and that while the level of protoplasmic drops did not vary, their position did. Rao and Hart (1948) and other workers have confirmed this view.

During the writer's investigations, whenever post-mortem examinations were performed, smears were prepared from all levels of the reproductive tract, from the testis, to the *ampullæ* of the *vasa deferentia*. In this way material has been studied from eight bulls at *post mortem*, and from one after castration.

Much work exists to show that abnormal sperm arise in the testis, and the possible role of nutrition has been studied (Cunningham and Hopkirk, 1935; Gunn *et al.*, 1942). Haq (1948) further stated that the sperm head is affected by spermatocytogenesis, that middle piece abnormalities arise from faulty spermiogenesis; and that semen showing disturbance of both class indicate generally defective spermatogenesis.

Incidental reports of agents which will produce abnormality of the sperm are of great help, and many now exist. Thus, Mercier and Salisbury (1947) found that chlorazene, when used as a clearing agent, caused some breakage of the sperm neck. Water may cause coiling of the tail (Walton, 1933), due presumably to osmotic effects. Rao and Hart (1948) found that storage of semen undiluted at 45° F. would cause bending of the middle piece or tail around drops of residual protoplasm. Bretschneider (1948) found that air-dried films fixed with dilute solutions of heavy metallic salts showed no abnormalities that could be detected by the electron microscope. Baylor, Nalbandov and Clark (1943), however, found that alcohol (presumably ethyl) caused distortion of the *Galea capitis*.

On the available evidence, the methods adopted of preparing smears as

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soon as possible after collection, after storage at 4° C., of allowing the smears to dry in air, and of fixing in methyl alcohol, as recommended by Cary and Hotchkiss (1934) and Gunn *et al.* (1942), are as reliable as possible at present.

Abnormal sperm can be sub-divided into two main groups, viz., (i) those arising during spermatogenesis, and (ii) those arising during passage through the epididymis.

Abnormalities of the head of the sperm arise during the formation of the head during spermatogenesis, from effects handed down from the precursors. Thus the persistent acrosome described by Teunissen (1945), believed by Hancock (1949) to be hereditary; the decapitation of Guernsey sperm which is also most probably hereditary, and in the head type described by Blake (1945), the abnormality must be determined by the make-up of the primitive germ cells. Where external effects cause the formation of an abnormal sperm head, these effects must act at the stage of spermatocytogenesis as deduced by Haq (1948). Such forms as elongate, and pear-shaped, can be demonstrated in smears of the testis.

Double heads arise from abnormalities of the spermatid, most probably derived from the spermatocytes. In bulls ejaculating many such heads, all stages of development can be found, from the spermatid with two nuclei, to the sperm with two heads, a bifid middle piece and a single tail. It is possible that the degenerating sperm clusters described by Haq may arise in a similar way to double heads. Thus it would appear that certain adverse effects retard the division of the spermatid protoplasm while allowing the nucleus to divide normally, or even to stimulate further division of the nucleus. The occurrence of double heads should be looked upon with suspicion.

Abnormalities of the sperm neck, such as weakness or swelling, arise during spermatogenesis, as also does abaxial attachment.

The remaining abnormal types can be divided, as stated above, into two main groups. Thickening and swelling of the middle piece, together with disturbance of the normal disintegration of the residual protoplasm, arise during spermatogenesis. The writer considers that the various bent and coiled forms arise during the passage of the sperm through the epididymis. The former types can be found on smears of the testis, while the latter types cannot.

The maturation types (coils and bends) can arise either by an increased death rate of the sperm due to adverse effects, or by a decrease in the rate of removal of degenerate forms. It is most likely that a combination of the two effects occur. This is especially important in view of the work of Hooker (1944) on the maturation of the interstitial cells of the testis, and of Barron and Haq (1948) on testicular hypoplasia, since in congenitally sterile bulls many sperm of these types are found.

(F) Discussion

In comparing the general characteristics of semen as found in this investigation with those of other workers, much agreement is apparent, and the fertile semen appears to agree well with other records.

(i) *Volume of ejaculate.*—The fertile semen examined showed a mean

volume of 4.37 ml., which is in close agreement with Herman and Swanson (1941) who found 4.38 ml., and with the findings of Anderson (1939) who found 4.4 ml. The writer's findings agree most nearly with the latter author, since young abnormal bulls (congenitally sterile group) showed a mean volume of ejaculate of 2.32 ml. or 53 per cent of the normal older bulls.

We detected an increase in volume with the second ejaculate, while third ejaculates were usually intermediate in volume.

(ii) *Motility.*—The mean motility of fertile bulls' semen was the highest of the series examined, thus agreeing with other workers. The fall in motility through the groups examined did not parallel the decrease in fertility. Congenitally sterile bulls showed the lowest degree of motility of all, but on occasions individual samples showed an appreciable motion. Some cases of acquired sterility (e.g., ABR 33) showed extremely good motility. It is the writer's experience that normal staining narrow heads in life show good motility. Spermatozoa having abnormality of the acrosome likewise show moderate motility on occasion. It is assumed by many workers that the duration of motility of abnormal sperm is reduced (Weismann, 1941) but whether this is in fact true is unknown. In our examinations, it was noticed that abnormal double-headed sperm always appeared dead to the opal blue test. Harvey and Jackson (1945) believe that only microsperm have any chance of fertilisation.

There is ample evidence to support the view put forward as long ago as 1920 by Williams, that motility does not constitute a standard for the measurement of the fecundating powers of semen. In conjunction with other tests, however, motility estimation is of great value.

(iii) *Density.*—In fertile bulls we have found an average density of 707,000 per mm.^{3}, with a range of from 295,000 to 1,672,000 per mm.^{3}; Lagerlof found a range from 300,000 to nearly 2,000,000 per mm.^{3} with an average of 800,000 per mm.^{3}.

The density of abnormal semen is of great interest, especially when considered together with the level of abnormal sperm. Thus Hotchkiss (1945), assuming that abnormal spermatozoa cannot fertilise, calculated the effective density of the ejaculate. We have confirmed the decrease in density of the second ejaculate, pointed out by Haq, and find that this effect becomes much more marked in infertile and sterile semen.

(iv) *Hydrogen ion concentration.*—The values we have found for the *pH* as estimated colourimetrically tend to be slightly lower than many records. The normal series examined by the writer gave an average figure of 6.33, compared to 6.75 (Anderson, 1942) and 6.47 (Herman and Swanson, 1941). The differences between bulls of good and poor fertility was also greater than that found by the latter workers.

While bulls with poor fertility generally have a slightly higher *pH*, infertile bulls with a low *pH* are not uncommon, and vice versa. Admixture with the accessory gland secretions during excitement, with unsuccessful ejaculation, invariably increases the *pH*. Raps and Cannon (1947) found a positive

ACTUAL AND EFFECTIVE DENSITIES OF SPERMATOZOA PER EJACULATE

(figures equal millions of sperm)

Group	*Ejaculate*	*Actual density*	*Effective density*
Fertile	I	2,862	2,534
	II	3,506	3,143
	III	2,826	2,572
Infertile 41% and over	I	1,898	1,512
	II	1,466	1,155
Infertile 21-40% ...	I	2,052	1,546
	II	846	644
	III	431	335
Infertile 4-20% ...	I	2,308	1,885
	II	2,533	2,097
	III	819	719
Acquired sterility ...	I	1,213	957
	II	2,473	2,044
	III	1,290	1,123
Congenital sterility ...	I	1,327	910
	II	475	354
	III	473	274

correlation between *pH* and husbandry, and as Haq has suggested that poor husbandry is one of the chief causes of infertility, this correlation is of great interest.

The relationship of *pH* in successive ejaculates is somewhat confused. Thus Anderson (1941) noted an increase in volume with successive ejaculation and a decrease in *pH* associated with an increased concentration of spermatozoa. In this respect, the present results agree more with Davis and Williams (1939) and Haq (1948) who each found a decrease in density with successive ejaculation. This the writer finds is linked with an increase in *pH*; thus the *pH* in normal semen is directly proportional to the volume of ejaculate. The decrease in density and increase in *pH* becomes more marked as the fertility rate declines. So that in infertile and sterile bulls the *pH* is inversely proportional to the volume, and follows from the decrease in effective density.

(v) *Types of abnormal spermatozoa.*—No comparable studies of abnormal types exist, but the general classification of types by morphology agrees most closely with that of Bretschneider (1948). In the present investigation we have not encountered sperm with the numbers of tails that he illustrates, and we regard the double tails of great rarity. It is in these respects that a comparative incidence is of great use.

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Our observations do not support the finding of Herman and Swanson (1941) that coiled tails are most common. Abnormalities of the tail formed only 3.17 per cent of abnormalities in normal bulls, and 0.79 per cent in abnormal bulls. Of these small percentages, coils form the great majority (78.40 per cent). The present investigation shows that the greatest proportion of abnormalities are those of the middle piece. Normal bulls 58.37 per cent, abnormal bulls 65.01 per cent. Of these middle piece abnormalities, bends without attachment of protoplasmic drops were most common, viz., 32.88 per cent.

Of all infertile bulls examined, 20.68 per cent were sterile from the commencement of their breeding career.

This group consisted of two cases of hypoplasia, two of Guernsey sperm decapitation, and one of detachment of the *Galea capitis* associated with a neuro-hormonal disturbance, together with one case of severe abnormality of the middle piece, showing no motility (ABR 15).

(vi) *Incidence of types of abnormal spermatozoa.*—This investigation has shown that although in general fertile semen contains the lowest numbers of abnormal sperm, and sterile semen the greatest numbers, when considered as total percentages there is no gradual gradation between the two extremes.

Our figures for abnormal spermatozoa in fertile semen (11.86 per cent) compare favourably with previous work, Lagerlof finding 10.7 per cent and Anderson 10.5 per cent and 10.6 per cent, while Herman and Swanson found 14.2 per cent for bulls of good fertility, and Erb, *et al.* (1942), found 12.7 per cent.

As the fertility rate drops to the 21 per cent level there is a steady increase in the percentage of abnormal forms; these consist partly of abnormalities of the head, and partly of middle-piece abnormalities. Between 20 per cent and complete acquired sterility, the trend does not progress. The percentage of abnormal middle pieces fall to a moderate level (8.6 per cent), while head abnormalities remain at a level of between 7 per cent and 8.33 per cent, i.e., at about the same level as the more fertile infertile groups. Between the two phases, however, there is a fall in motility and also in density while normal staining elongated sperm heads increase in average occurrence, and occur in 100 per cent of bulls.

It has been already stressed that no single test can be a foolproof guide in semen examination, and that morphological studies must be made in conjunction with other tests and each case assessed on its merits. Between acquired sterility and 20 per cent fertility the greatest discrepancy seems to exist by morphological analysis.

Abnormalities of the head, which are especially important in the writer's experience, are, first, those affecting the *Galea capitis*; secondly, those affecting the anterior staining character of the sperm, and lastly, gross variation in size or form of the heads. Any increase above 1 per bull (0.33 per cent) of the more rare abnormalities, such as eosinophillic heads or hyperbasophillic macro rounds heads, or hyperbacophillic micro double heads, should be regarded with

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suspicion. When 70-100 per cent of head abnormalities are of one type, and this exists above 7 per cent, then infertility should be considered.

Abnormalities of the middle piece are of equal importance to those of the head, since motility is nearly always affected. Thus swelling, thickening and coiling of the middle piece reduces the motion of the sperm to the greatest extent. Bends of the middle piece are slightly less serious, unless present in moderately large amounts, i.e., 12-15 per cent. Sperm showing bends may later straighten out.

Abnormalities of the tail are of least importance, and we have not yet encountered a case in which a large proportion of tail abnormalities were present. At the low incidence at which they have been encountered significance is small.

In considering the various levels of fertility, it appears that the first abnormal finding in semen is a deficiency of sperm replacement evidenced by the increased drop in density between ejaculates, coupled at about the same time with an increase in abnormal forms, especially those of the middle piece. The second stage is indicated by decrease in the percentage of actively motile sperm, followed thirdly by a decrease in the vigour of sperm movement.

From the data available, it is suggested that for the highest level of fertility (80 per cent and over) each ejaculate should contain at least 2,500,000,000 sperm of which 70 per cent or more should be very actively motile, and which should not contain more than 2.5 per cent head abnormalities, 0.5 per cent tailless heads, 3.5 per cent middle-piece abnormalities, and no abnormal tails.

Ejaculates which consist of from 1,500,000,000 to 2,500,000,000 sperm showing 60 per cent to 70 per cent vigorous motility, and have about 4 per cent head abnormals, 5 per cent tailless heads, 10 per cent middle pieces and 1 per cent abnormal tails will probably give 60 per cent to 80 per cent fertility.

Ejaculates showing about 1,000,000,000 sperm of which 30-50 per cent are actively motile and show about 7.5 per cent head abnormals, 5 per cent tailless head, 15 per cent middle piece, and 1 per cent abnormal tails, are likely to give moderate fertility of 40 per cent to 60 per cent.

Below this level prediction is of little use compared to the judgment of recovery, which is only likely with prolonged rest, good feeding and treatment.

(G) Summary

(1) Ninety-one semen samples from 29 infertile or sterile bulls were examined and compared to 33 samples from 14 fertile bulls. In addition, various other abnormal conditions were investigated.

(2) The fertility rates of the infertile bulls ranged from 0-65 per cent compared with 50 per cent to 92 per cent for the fertile bulls.

(3) The bulls were examined in their usual surroundings, methods of husbandry and feeding were noted. All animals were examined clinically.

(4) Sheath washings and semen collections were made on all possible occasions. The semen was examined for appearance, quantity, motility *pH*, and approximate density within five minutes of collection. Samples were then slowly cooled to 4° C., and further examined in the laboratory within one to four hours. In the laboratory the samples were examined, diluted,

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1 : 100 with normal saline, during estimation of density and tissue cells. Flood smears and direct pull smears were prepared and stained with hæmalum and eosin. The tissue cells other than spermatozoa have been examined on flood smears according to the methods of Haq.

(5) A detailed and varied classification for abnormal spermatozoa has been devised for recording the different types. Abnormalities of the head were classified according to their staining capacity, size, and shape into a table containing 59 sub-divisions. Abnormalities of the middle piece (connecting piece or body) have been classified according to morphological form into a table of 28 divisions. The tail abnormalities have been grouped into 7 sub-divisions.

(6) Use of these classifications has given a detailed picture of the types of sperm encountered in fertile animals under field conditions and in infertile or sterile bulls. The abnormal bulls have been divided into five groups according to their prevailing fertility rate.

(7) Fertile semen contained the least number of abnormal spermatozoa. Increasing numbers of abnormal forms were found through two groups of infertile bulls (21 per cent to 41 per cent, and over 41 per cent). Bulls in the 4 per cent to 20 per cent and acquired sterility groups did not continue this trend, although the percentage of abnormals in these groups was above normal. Congenitally sterile bulls showed the highest percentage of abnormal spermatozoa chiefly abnormalities of the middle piece.

(8) The average motility was reduced in all the infertile and sterile bulls, although good motility was occasionally seen.

(9) A small proportion of tailless heads and headless tails was found on many occasions. Abnormal tailless heads have been included in the total of abnormal heads. An increased occurrence of normal tailless heads was found in abnormal bulls.

(10) A fall in density, an increase in the difference in density between consecutive ejaculates, poor motility and an increased *pH* are all signs of poor fertility.

(11) In fertile semen the *pH* varies directly with the volume, so that as the volume increases so the *pH* increases, but in infertile semen the *pH* varies inversely as the volume.

(12) The best fertility rates are obtained with ejaculates containing about 2,500,000,000 sperm showing a motility of at least 60 x 3 and having less than 4 per cent head abnormals, less than 8 per cent middle-piece and 0 per cent to 0.5 per cent tail abnormalities.

(13) Fertile semen may contain any single type of abnormality in very small amounts. In infertile semen the incidence is increased greatly. Abnormality of the anterior vesicle and a large proportion of any one type of abnormal are severe changes resulting most probably in sterility. Five per cent to 10 per cent of any single type of abnormal sperm will reduce fertility.

(14) Abnormalities of the middle piece interfere with fertility by reducing motility. They may, if present in amount, cause complete sterility. Swollen and thickened types are most serious.

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REVIEWS

THE DOG BREEDER'S MANUAL, by Eric Fitch Daglish. London: J. M. Dent & Sons, Ltd. Price 12s. 6d.

THE average man likes to think that he has a better dog than his neighbour. This has been, and always will be so, and it is the basic stimulus behind the dog-breeding industry. It has led to the development and improvement of our many breeds and given us that perfection of canine grace and form which delights the spectator at a championship show. Now ideas or conceptions for the improvement of the dog are, from man's point of view, not completely altruistic, for just as one's dog is the greatest flatterer ever, so also does his master in his vanity, attract attention to himself by virtue of his dog. Perfect form and, above all, a distinguished ancestral tree count for much. The latter in particular, for although in the modern state one may scorn "blue blood" in people, in the case of our dogs it is a much-prized attribue. One of "John Citizen's" most sacred possessions is a tattered piece of paper which testifies that his dog is descended from "kings." On the slightest provocation this sheet will be displayed with great pride.

Other things count also. The ugly dog, the physically abnormal dog, the sagacious dog all have their devotees.

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It is from this demand to possess the unusual or the distinguished dog that the dog-breeding industry has evolved.

Now, some folk seem to be able to breed good dogs, as it were, in their stride; others, and they are in the majority, to their great chagrin, confess failure after a life-time of effort. One man can produce champions by the dozen—the other fails miserably.

However, such is the ideal that success or failure only spurs the enthusiast to further effort.

Mr. Daglish must have been aware of this great desire amongst men when he sat down to compile his book.

How is it that some men have been able to breed good stock always? Have they some secret recipe, is it just intuition, or is it that they are lucky, in their interpretation of the old tag, " Like begets like "? Mendel, Galton, Darwin and Pearson opened the door, and since then the science of genetics has widened and illuminated our knowledge.

Much remains to be elucidated, but there is no doubt that even with the use of present knowledge the art of breeding is simplified, for by precise mating one can almost design the progeny.

Scientific literature is apt to become very involved and only intelligible to workers in the specific sphere. It is not understood easily by the average person, and this is true as regards genetics. Dog breeders have been waiting for someone to put abstruse, scientific jargon into plain, easily understood language.

Daglish has attempted this task, and he has gone a long way towards success.

He also incorporates within the book much information on such subjects as general care, choice of sire and dam, the period of heat and mating, care during pregnancy, whelping, care of the bitch and her puppies, and advice on weaning and rearing. All these items are factual and add interest to the book.

Dog breeders, and even those with professional and scientific knowledge, will read this book with interest and profit.

THE SHEPHERD'S GUIDE TO THE PREVENTION AND CONTROL OF THE DISEASES OF SHEEP, by J. Russell Greig. Edinburgh: His Majesty's Stationery Office. Price 3s.

THIS book was compiled primarily as a guide to shepherds, and there is no doubt that the average modern shepherd could peruse it with understanding and profit. Language has been made as simple as possible and great detail avoided, but there can be no doubt that competent professional men will also find pleasure and instruction in its pages. The inclusion of Gaelic and Welsh names for the varibus diseases is an asset, and the same can be said of the glossary.

The author is a recognised authority, and he has the gift of setting down and accentuating essential things so that they can be understood by laymen.

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The names of his collaborators are almost sufficient testimony to recommend this book.

The reviewer, a person with some experience in sheep and their diseases, has read the book with great interest, and he can recommend it to all who are interested in sheep and sheep farming.

QUESTIONS AND ANSWERS: VETERINARY. Evanston, Illinois: American Veterinary Publications, Inc. Price $4.00 in U.S.A., 32s. 6d. sterling elsewhere.

ALL those who have been reared in a good Christian environment will know what the Catechism means. Theology has been taught in this manner for many centuries, and there is no doubt that the path of life is made smoother and easier, and one can resolve the mind of much tribulation if one can refer to a specific plan of action which has been laid down to suit the circumstances of the moment. Now, this method of instruction was designed to suit those who had not the time or ability to think for themselves, and it flourished best in the Victorian elementary school and in the armed services. "Theirs was not to reason why, but just to do as they were told." One might criticise the method of instruction, but it worked, and results were good.

Now, as the twentieth century got under way and knowledge was advanced, the learned ones, in their conceit, were fain to condemn a method of instruction which followed certain defined or hard and fast rules. The emphasis was placed on the "reason why," and so important did this become that the "what to do" was ignored, and the end result was of no consequence at all.

If we look to the Medical and Veterinary fields we find that "diagnosis" became the be-all and end-all of all effort, but treatment, the use and compounding of drugs, and hygiene and general care became anybody's business. Anybody's business is nobody's business, and so in these enlightened days of the mid-twentieth century it is good to see a reversion to an old system of education. The modern scientific veterinary surgeon can confine his attention to diagnosis and state a name. Thereafter any casual attendant can, by use of this name, and a book such as this, give the best, the most scientific, and the most modern treatment. The result may or may not be better, but then there was always a recognisable percentage of good results and of bad results which, fortunately, were balanced so as not to be too much to the detriment of the practitioner. In spite of all these verbal arguments this book will serve a useful purpose, especially to the young graduate, for he, although of a more scientific turn of mind than his predecessors, is not so good on the practical side, i.e., knowing what to do especially in emergency.

RESTRAINT OF ANIMALS, by John Leahy and Pat Barrow. Department of Anatomy, New York State Veterinary College, Cornell University.

Two hundred and thirty-four pages, packed with most useful information. It is illustrated by many simple line drawings which are very clear and easy to understand. The few differences in terminology offer no difficulty.

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The chapter on ropes is very interesting, for it explains the parts of a rope, methods to prevent unravelling, how to splice and mend, and how to tie the various knots. The methods of restraint in the various animals are described extraordinarily well.

The Americans evidently have more methods of restraint of the pig than we do, but not so of the sheep, for no methods of restraint of that animal have been included.

The pneumatic Elizabethan type of collar for the dog is intriguing, and would certainly prevent damage to household goods, if not to the dog.

The chapter relating to the fur-bearing animals is likely to be useful to us if the business of rearing these animals should develop here.

The methods advocated for the restraint of poultry are simple and efficient and require no elaborate equipment.

This book should be very useful to veterinary students, and the mature graduate will cull many " tips " from its pages.

MEAT HYGIENE, by A. R. Miller, D.V.H., LL.B., Chief of the Federal Meat Inspection Service, U.S. Department of Agriculture, Washington, D.C. London: Henry Kimpton. Price 52s. 6d.

THE subject of meat hygiene is too vast to be dealt with effectively in one small volume. In this book the author has condensed his preliminary chapters to such an extent that they have but little of interest to veterinary readers. It is, however, these chapters that would have interested us most had they been expanded to lengths suitable for their subject. Thus, the first chapter, headed " History " consists only of brief notes on the origins of Jewish law, the Florentine law in 1200-1300 A.D., and American law at the present time, all confined within two pages. Surely the history of meat hygiene consists of more than this. The next two pages are all that are devoted to the " Elements of Food Hygiene." Ante-mortem inspection is dealt with more fully, but even then the chapter contains little more than a list of 18 diseases detectable before slaughter. Post-mortem examination of carcasses is dealt with in a similarly brief manner, but this chapter has some excellent photographs that go near to justifying the whole book.

One disease only, Trichinosis, receives a complete chapter to itself, and though this has not yet become a serious problem in the United Kingdom the possibility that it may become so at any time must be borne in mind.

The chapter on the " Physical and Chemical Characteristics of Meat and the Principal Organs " may provide useful refreshers for those whose memory of physiology and histology is getting rusty, but it is strange that the subject of anatomy has been completely ignored.

More lengthy chapters are devoted to what I may call the " Processing " of meat and its bye-products, though this is a side of the subject that rarely enters the veterinary surgeon's province. The chapter on " Deterioration " is, however, of interest to all.

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EARLY EMBRYOLOGY OF THE CHICK, by Bradley M. Patten. Fourth edition. London: H. K. Lewis & Co., Ltd. Price 25s.

THE fourth edition of this well-known book will require little introduction, for, despite the interval of twenty years, the general plan is the same as in the previous edition; it is only necessary to remark on the more important alterations.

The text, as readable as before, has been revised throughout and many new references have been added: the accounts of the formation of the germ layers and of gastrulation have been expanded and are now more comparative in their scope and describe these processes in other vertebrate classes. The illustrations are even clearer, because they are larger, than before.

Most veterinary readers will prefer the same author's "Embryology of the Pig," but to those specifically interested in avian embryology this book can be recommended unreservedly.

The production of the book is in keeping with the quality of the text.

LA MEDICINA VETERINARIA EN LA EDAD MEDIA,* by C. Ruiz Martinez.

THIS book, published on the occasion of the first Gran Columbiano Veterinary Congress held at Caracas in 1948, contains an interesting outline of the knowledge, status and practice of veterinary science in the Middle Ages.

A chapter on the background of the period introduces the main text, which is in two major divisions. In the first the development of veterinary science and animal husbandry in the countries under Moorish and Arabian rule is described. The second part is concerned with the countries of European civilisation. In each section the principal writings are analysed in some detail, and it is interesting to compare the more rational approach of the Arabs with the magico-religious attitude dominant in the western countries. In both parts one finds recorded accurate observations, of the quality that enabled the Arabs to recognise the method of spread of dourine, side by side with the most irrational therapeutics. The author wisely praises the former and shows a tolerant understanding of the latter.

The twenty full-page illustrations add greatly to the interest, and it is unfortunate that several are reproduced so poorly: especially interesting is the picture of an early attempt at blood transfusion.

This book is yet another reminder of the need for a history of veterinary medicine for the English reader.

* Ministerio de Agricultura and Cria, Venezuela.

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